METHODOLOGY FOR THE DETERMINATION OF CRITICALITY CODES AND RECERTIFICATION INTERVALS FOR TANK MOUNTED AIR COMPRESSORS (TMAC) AND BASE MOUNTED AIR COMPRESSORS (BMAC)

by

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EXECUTIVE SUMMARY

The purpose of this methodology is to provide a procedure based upon NASA Guidelines and Standards and National Consensus Codes which define a range of allowable inspection and certification requirements dependent upon the remaining life, the potential hazard and mission requirements of a particular system. These procedures should not be construed to guarantee the absolute safety of the particular systems but rather that they may be accordingly operated at an "acceptable level of risk."

The methodology establishes a "Criticality Code" based on a Risk Assessment Analysis, a Mission Essentiality Analysis and a Remaining Life Analysis. Criticality Codes 1, 2 and 3 are then assigned based on these analyses and provide Inspection Intervals of 1, 3 and 6 years respectively with complete recertification every 6 years. The Risk Assessment Analysis is performed in accordance with the NASA Basic Safety Manual, NHB 1700.1, and is judged on the severity and probability of the occurrence of the worst case accident for the particular pressure vessel or system. The Mission Essentiality Analysis is derived from NMI 1710.3B, Design, Inspection and Certification of Pressure Vessels and Pressurized Systems. It considers the systems' capability for safe mission conduct, any redundant capabilities and the cost or implications of system failure. The Remaining Life Analysis is developed from the National Board Inspection Code, ANSI/NB-23 and is based on minimum wall thicknesses (as determined by the ASME Boiler and Pressure Vessel Code), corrosion rates (as determined by the requirements of the National Board Inspection Code) and the actual inspection intervals for the particular system.

All decisions, judgements and considerations used in the aforementioned analyses are formally recorded and become a part of the permanent record and recertification files which can be recalled, reviewed and/or revised at any time should the situation warrant.

DESIGN TEMPERATURE - The metal temperature used in the design of a vessel for determining the minimum required thickness of the components. Also, the metal temperature used for selecting the maximum allowable stress for the materials used in the vessel.

DISCREPANCY - Condition of any hardware or software in which one or more characteristics do not conform to the specified requirements.

EFFICIENCY OF A WELDED JOINT - A numerical (decimal) quantity expressed as a multiplier of the allowable stress value used in the design of a joint.

HAZARD - Existing or potential condition that can result in or contribute to a mishap with a risk of harm.

HAZARD LEVEL CATEGORIZATION - Hazards are classified in following four categories:

1. Category I - Catastrophic - Hazardous occurrence whose worst-case effects will cause death or severe injury to personnel or loss of system.

2. Category II - Critical - Hazardous occurrence in which the worst-case effects will cause severe personnel injury (hospitalization) or major system damage (performance impairment), or will require immediate corrective action to prevent personnel death or loss of system.

3. Category III - Marginal - Hazardous occurrence whose worst-case effects can be counteracted or controlled without serious personnel injury (first aid) or equipment damage.

4. Category IV - Negligible - Hazardous occurrence in which the worst-case effects could not result in personnel injury or equipment damage.

HAZARD PROBABILITY - Aggregate likelihood of occurrence, stated in qualitative or quantitative terms, of the individual hazardous events that create a specific hazard.

HAZARD SEVERITY - Assessment of the worst-case harm from credible mishaps that could occur because of a specific hazard.

HYDROSTATIC TEST - A test performed on a pressure vessel or system in which the vessel or system is filled with a liquid (usually water) and pressurized to a designated level in a manner prescribed in the applicable code.

IN-SERVICE INSPECTION - Inspection performed after a system has been initially put into service. The system may have to be inoperative during such inspection.

MAXIMUM ALLOWABLE STRESS VALUE - The maximum unit stress permissible for a specific material used in the appropriate design formulas.

GLOSSARY OF TERMS

CATASTROPHIC CONDITION - Hazardous condition that may cause death, major system destruction or loss of crew or vehicle.

CATASTROPHIC FAILURE - Failure that causes loss of life or loss of a system.

CERTIFICATION - The documented status that qualifies a vessel or system to operate in the service for which it is intended.

COST (MISHAP) - Direct costs of a NASA mishap for repair, retest, program delays, replacement or recovery of NASA materials including hours, material, and contract costs. Not included are the indirect costs of a mishap for cleanup, investigation, injury or normal operational shutdown.

CREDIBLE CONDITION (EVENT) - Condition (event) that can occur and is likely to occur. A probability of occurrence greater than 10% is generally considered as credible.

CRITICAL CONDITION - Hazardous condition that may lead to a mishap with severe occupational injury or illness, or major damage to property or equipment.

CRITICAL FUNCTION - Any system, equipment or facility function that, by not performing as expected, causes a critical condition.

CRITICAL ITEM - Single failure point (single point of failure) in a life or mission-essential application, that, as determined by the results of failure mode and effects analysis or other safety analysis, is essential to the safe or reliable functioning of a system or subsystem.

CRITICALITY - Categorization of a hardware failure, software error, or fault based upon an evaluation of the degree of impact of that failure, error or fault on the development or operation of a system (often used to determine whether or when a failure, error or fault will be corrected).

DERATED VESSEL OR SYSTEM - A vessel or system that has been judged to be unsafe, unsuitable or unnecessary for continued operation at its original design pressure and/or temperature limits, and has been recertified to operate at a lesser pressure and/or temperature limit range.

DESIGN PRESSURE - Used for the design of a pressure vessel to determine the permissible thickness or physical characteristics of its parts. Design pressure must constitute the most severe conditions of coincident pressure and temperature expected in normal operation, and the difference in pressure between vessel inside and outside or in two chambers of a combination unit. (See Maximum Allowable Working Pressure).

MAXIMUM ALLOWABLE WORKING PRESSURE - Maximum gage pressure permissible at the top of a pressure vessel or other component, in its normal operating position for a designated temperature. It is used for the pressure setting of pressure relief devices protecting a component based on its allowable stress value and functional capability. This pressure is synonymous with "rated pressure." The design pressure may be used in cases where the value of maximum allowable working pressure is not found.

MAXIMUM EXPECTED OPERATING PRESSURE - Maximum pressure at expected operating temperatures at which a pressurized system or component actually operates in a particular space vehicle or ground support application. It includes the effects of environmental conditions or vibrations, vehicle acceleration, pressure surge, fluid shock, thermal degradation of strength, and relief valve tolerance. This pressure is synonymous with maximum operating pressure or maximum working pressure.

MAXIMUM OPERATING PRESSURE - Maximum pressure at which the system or component actually operates in a particular application. During design it is synonymous with maximum expected operating pressure for calculating the specified factor of safety. If a lower pressure setting is to be applied during normal operations, it will be used to calculate the actual factor of safety.

MISHAP - Event that results in death, injury or illness; in damage to property or equipment; or in a mission or test failure that has significant program impact or visibility.

MISSION CRITICAL - Item or function that must retain its operational capability for safe mission conduct.

NATIONAL CONSENSUS CODE/STANDARD - Any standard or modifications thereof which (1) has been adopted or promulgated by a nationally recognized standards-producing organization under procedures whereby it can be determined by the Secretary of Labor or by the Assistant Secretary of Labor for Occupational Safety and Health that persons interested and affected by the standard have reached substantial agreement on its adoption; (2) was formulated in a manner that afforded an opportunity for diverse views to be considered; and (3) has been so designated by the Secretary or the Assistant Secretary, after consultation with other appropriate Federal agencies. A standard, as used in this definition, requires conditions or activities necessary or appropriate to provide safe and healthful employment and places of employment.

OPERATING OR WORKING TEMPERATURE - The metal temperature that will be maintained in the part of the vessel under consideration during normal operation.

OPERATING PRESSURE - The pressure at the top of a vessel at which it normally operates. It shall not exceed the maximum allowable working pressure.

PNEUMATIC OR PNEUMOSTATIC TEST - A test performed on a pressure vessel or system in which air or gas is introduced and pressurized to a designated level in a manner prescribed in the applicable code.

PRESSURE SYSTEMS ENGINEER - A person who has the necessary qualifications to evaluate designs with respect to code conformance and the authority to perform or cause to be performed the evaluation of results or any and all tests, inspections and examinations performed on pressure systems in order to determine the next period of inspection, derating requirements, rerating requirements, modifications, repairs, etc.

PRESSURE VESSEL - Any vessel used for the storage or handling of gas or liquid under positive pressure. Included are components of systems such as heat exchanger shells and drying towers and other shell structures.

PRESSURIZED SYSTEM - Grouping of pressure vessels or pressurized structure, tubing, pipe, hose, fittings, valves, pressure relief devices, etc., that are exposed to and designed for pressure.

PROBABILITY - Likelihood that a given event will occur per unit opportunity for the occurrence.

PROOF TEST - A pressure test performed to establish the maximum allowable working pressure of a vessel, system or component thereof; (1) when the strength cannot be computed with a satisfactory assurance of accuracy; (2) when the thickness cannot be determined by means of the design rule of the applicable code or standard; or (3) when the critical flaw size to cause failure at the certified pressure cannot be identified by other nondestructive test methods. This test shall be performed in a manner equivalent to one of the methods specified in Paragraph UG-101 of the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1, latest edition.

RECERTIFICATION - The procedure by which a previously certified vessel or system, by appropriate tests, inspections, examination and documentation, is qualified to continue or be returned to operations at the designed pressure.

RECERTIFICATION INTERVAL - The period of time between recertification when a certified status is maintained through documented periodic examinations and inspections to determine vessel or system condition (time between major inspections).

REDUNDANCY - Use of more that one means to accomplish a given function and where more than one means must fail before the function fails.

RELIEF VALVE SET PRESSURE - See paragraph UG-125, Section VIII, Division I, ASME Boiler Code and Part AR, Section VIII, Division 2, ASME Boiler Code.

RISK - Exposure to the chance of injury or loss. It is a function of the possible frequency of occurrence of an undesired event, of the potential severity of resulting consequences and of the uncertainties associated with the frequency and severity.

RISK ASSESSMENT - Process of qualitative risk categorization or quantitative risk estimation, followed by the evaluation of risk significance.

SYSTEM - Composite of hardware, software, procedures and skills that perform a functional role.

TANK - Any vessel used for the storage or handling of liquids where the internal pressure is only a function of the liquid head or a combination of liquid head and vapor pressure.

UNFIRED PRESSURE VESSELS AND SYSTEMS - In the context for which this phrase is used in this guide it is intended to cover all pressure vessels and pressurized systems for which in-service inspection is not otherwise covered by codes and standards.

VACUUM SYSTEM - An assembly of components under vacuum, including vessels, piping, valves, relief devices, pumps, expansion joints, gages, etc.

VACUUM VESSEL - A vessel in which the internal pressure has been reduced to a level less than that of the surrounding atmosphere.

LIST OF FIGURES

INTRODUCTION

1.0 Scope

This methodology shall be used to determine inspection procedures and intervals for components contained within tank mounted air compressor systems (TMAC) and base mounted air compressor systems (BMAC) included in the Pressure Vessel and System Recertification inventory at the Goddard Space Flight Center.

1.1 Purpose

The purpose of this document is to establish and document a method of determining TMAC and BMAC inspection procedures and intervals based on NASA specifications and National Consensus Codes to insure that all such systems are operated at an "acceptable level of risk."

1.2 Criticality Codes, Definition Of

For the purpose of this methodology, a Criticality Code is a number 1,2 or 3 assigned to a pressure vessel, system or component based on the results of a Risk Assessment Analysis, a Mission Essentiality Analysis and a Remaining Life Analysis for the purpose of determining the required recertification interval.

1.2.1 A Criticality Code 1 indicates that the vessel, system or component being analyzed has a Risk Assessment Code of 3 or is Mission Essential with no redundancy, or has a Remaining Life of 6 years or less, or any combination of the above conditions.

1.2.2 A Criticality Code 2 indicates that the vessel, system or component being analyzed has a Risk Assessment Code of 4 or is Mission Essential with redundancy, or is not Mission Essential but has a cost of failure greater than $5,000, or has a Remaining Life of 6 to 12 years, or any combination of the above conditions.

1.2.3 A Criticality Code 3 indicates that the vessel, system or component being analyzed has a Risk Assessment Code of 5 or 6, and is not Mission Essential and has a cost of failure less than $5,000, and has a Remaining Life greater than 12 years.

1.3 Requirements

NHB 1700.6, Guide for In-service Inspection of Ground-Based Pressure Vessels and Systems requires that inspection intervals used for specific systems should be based on detailed analyses and examination. It further requires that the results of these analyses be fully documented to clearly

show how the detailed analyses and examination, when considered on an integrated basis, provide appropriate safety for the service life of the system. It should include the rationale for deviations from codes or this Guide and provide support for the resulting in-service inspection and recertification plan.

1.4 Determination of Recertification Intervals

To determine the Inspection and Recertification Intervals, follow the decision logic of Figure 1 and the following paragraphs whose numbering corresponds to the numbering of the logic diagram blocks.

1.4.1. The Risk Assessment Criticality Category will be determined by following the procedures outlined in Chapter 2. If the Risk Assessment Criticality is Category 1, proceed to block 6. If the criticality is 2 or 3, proceed to the appropriate Mission Essentiality block 2.

1.4.2. The Mission Essentiality Criticality Category will be determined by following the procedures outlined in Chapter 3. If the Mission Essentiality Criticality is Category 1, proceed to block 6 of the Criticality is 2 or 3, proceed to the appropriate Remaining Life block 3.

1.4.3. The Remaining Life Criticality Category will be determined by following the procedures outlined in Chapter 4. If the Remaining Life Criticality is Category 1, proceed to block 6. If the Criticality is 2 or 3, proceed to the appropriate block 4 or 5.

1.4.4. If the Pressure Vessel Criticality Code is 3, inspect the pressure vessel at the lesser of 6 years or 1/2 of the remaining life. See Figure 8, Chapter 5 for component inspection requirements.

1.4.5. If the Pressure Vessel Criticality Code is 2, inspect the pressure vessel at the lesser of 3 years or 1/2 of the remaining life. See Figure 7, Chapter 5 for component inspection requirements.

1.4.6. If the Pressure Vessel Criticality Code is 1, inspect the pressure vessel annually. See Figure 6, Chapter 5 for component inspection requirements.

1.5 Documentation

The Pressure Vessel Criticality Code and the recertification interval shall be documented on the Pressure Vessel Criticality Code and recertification Interval Documentation Form (Attachment 1) and be maintained in the Recertification System files.

METHODOLOGY FOR THE DETERMINATION OF RECERTIFICATION INTERVALS

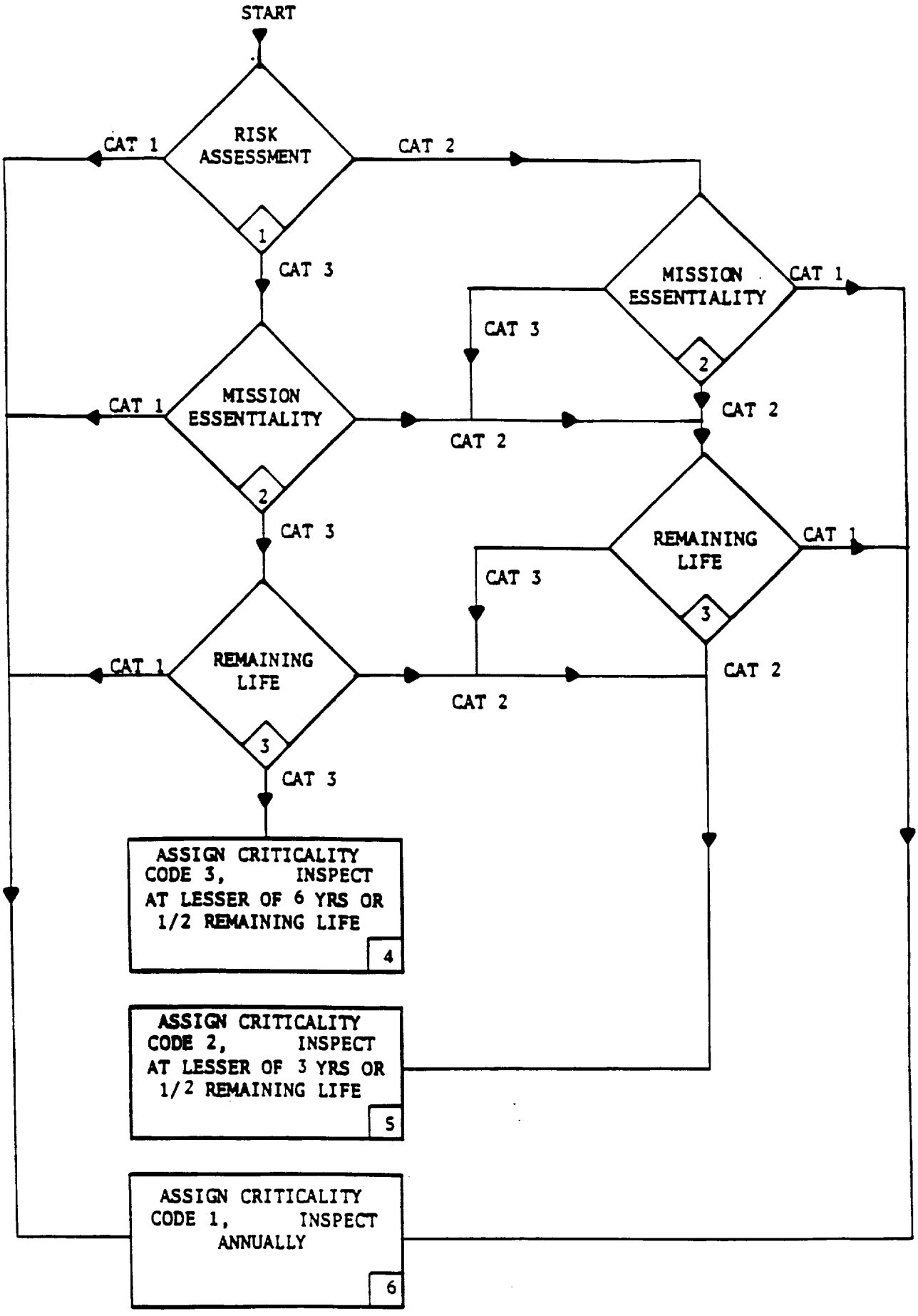

FIGURE 1

RISK ASSESSMENT

2.0 Risk Assessment, Definition Of

The process of qualitative risk categorization or quantitative risk estimation, followed by the evaluation of risk significance. It provides for an estimation of the potential severity and probability of occurrence of a system failure which then allows for the assignment of a quantitative Risk Assessment Code. (NASA Basic Safety Manual NHB 1700.1(V1-A) Proposed APPENDIX A, Glossary of Terms).

2.1 Requirements

Recertification of Pressure Vessels and Systems will be prioritized according to the risk or hazard of the potential failure using risk assessment techniques. (NMI 1710.3B, Design, Inspection and Certification of Pressure Vessels and Pressurized Systems).

2.2 Determination of Risk Assessment Code (NASA Basic Safety Manual NHB 1700.1 (V1A)).

The decision to assume risk is a management responsibility and should be based on all relevant factors. The potential severity and probability of a mishap should be a major consideration in that decision.

2.2.1 Definitions

NASA hazardous conditions or operations will be assigned a severity and probability index based on the following:

a. Severity An assessment of the worst potential consequence, defined by degree of injury, illness or property damage which could occur. Severity classification will be identified as follows:

1) Class I - Catastrophic - may cause death or major system destruction.

2) Class II - Critical - may cause severe injury, severe occupational illness or major property damage.

3) Class III - Marginal - may cause minor occupational illness or property damage.

4) Class IV - Negligible - probably would not affect personnel safety or health but is a violation of specific criteria.

b. Probability The likelihood that an identified hazard will result in a mishap based on an assessment of such factors as location, exposure in terms of cycles or hours of operation and affected population. Probability will be estimated as follows:

1) Estimate A - Likely to occur immediately

2) Estimate B - Probably will occur in time

3) Estimate C - May occur in time

4) Estimate D - Unlikely to occur

2.2.2 Risk Assessment Codes

The overall assessment of risk of a NASA hazardous operation will be based on both the severity class and probability estimate. A single number Risk Assessment Code (RAC) will be assigned to each deficiency code as shown in the matrix in Figure 2. This does not preclude the use of locally developed systems for risk assessment for local purposes only.

		Probability Estimate			
		A	B	C	D
Severity Class	I	1	1	2	3
	II	1	2	3	4
	III	2	3	4	5
	IV	3	4	5	6

Figure 2

RAC's 1 will be considered imminent danger and require immediate attention and initiation of abatement procedures. RAC's 2 will be considered serious and require priority attention. All RAC's 3-6 are nonserious and will be used in establishing the Criticality Category for determining inspection and recertification intervals.

2.3 Determination of Risk Assessment Criticality Category

Once the Risk Assessment Code (RAC) has been assigned, the Risk Assessment Criticality Category can be determined. Criticality categories will be assigned to each Risk Assessment Code as shown in the matrix in Figure 3.

		Criticality Category
Risk Assessment Code	1	Red Tag
	2	Red Tag
	3	1
	4	2
	5	3
	6	3

Figure 3

2.4 Documentation

The maximum credible hazard, severity classification, probability estimate, Risk Assessment Code (RAC) and Risk Assessment Criticality Category shall be documented on the Pressure Vessel Criticality Code and Inspection Interval Documentation Form (Attachment 1) and be maintained in the Recertification System files.

MISSION ESSENTIALITY

3.0 Mission Essential, Definition Of

A system element or function which must retain its operational capability and integrity for safe mission conduct is considered to be "mission essential." This criticality category assesses whether the system in question is essential to conduct safe mission operations, and whether loss of such system would result in severely restricted activities. (NASA Basic Safety Manual NHB 1700.1 (V1-A) Proposed Appendix A, Glossary of Terms).

3.1 Requirements

If the hazard potential of two or more systems are equal, then the mission essentiality of the systems will be considered when determining priorities (NMI 1710.3B Design, Inspection and Certification of Pressure Vessels and Pressurized Systems).

3.2 Determination of Mission Essentiality Criticality Category

To determine the Mission Essentiality Criticality Category, follow the decision logic of Figure 4 and the following paragraphs whose numbering corresponds to the numbering of the logic diagram blocks.

3.2.1 Does the pressure vessel or system support flight operations or other critical functions? Will the failure of this vessel or system result in a delay or cancellation of flight operations or other critical functions?

3.2.2 Is there a redundant support capability that would allow flight operations or other critical functions to continue in the event of failure of the subject pressure vessel or system?

3.2.3 Is the cost of a catastrophic failure of the subject pressure vessel or system greater than $5,000? The cost of failure should include not only the replacement costs of the pressure vessel or system, but also any costs associated with the repair of damage to other systems, equipments or structures as the result of a catastrophic failure.

3.2.4 If the subject pressure vessel or system supports flight operations or other critical functions and there is not a redundant support capability, assign Mission Essentiality Criticality Category #1.

3.2.5 If the subject pressure vessel or system supports flight operations or other critical functions and there is a redundant support capability or if the subject pressure vessel or system does not support flight operations or other critical functions but the cost of failure is greater than $5,000, assign Mission Essentiality Criticality Category #2.

3.2.6 If the subject pressure vessel or system does not support flight operations or other critical functions and the cost of failure is less than $5,000, assign Mission Essentiality Criticality Category #3.

3.3 Documentation

The answers to all decision logic questions on Figure 4 along with the Mission Essentiality Criticality Category shall be documented on the Pressure Vessel Criticality Code and Inspection Interval Documentation Form (Attachment 1) and be maintained in the Recertification System Files.

MISSION ESSENTIALITY DETERMINATION

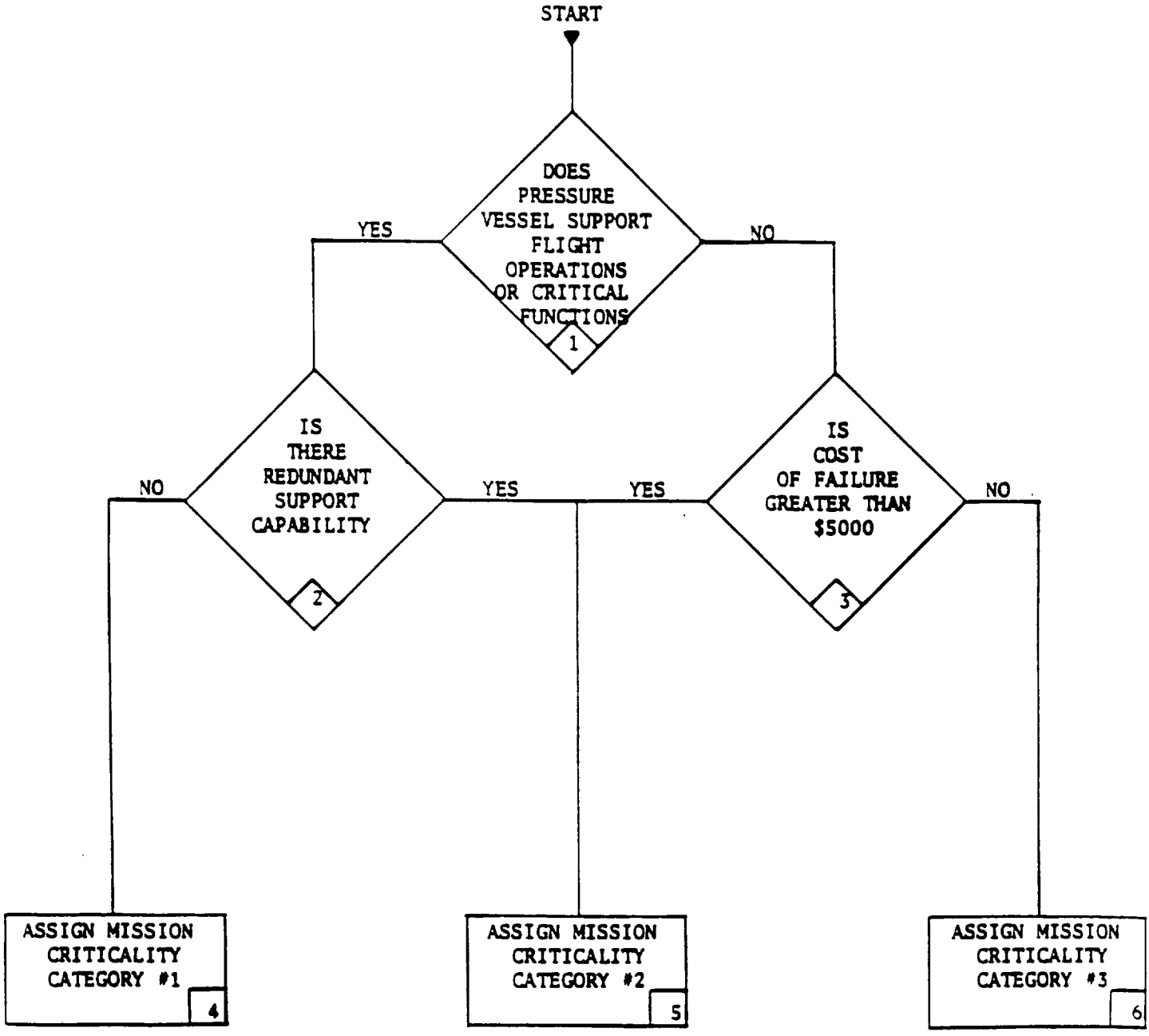

FIGURE 4

REMAINING LIFE

4.0 Remaining Life, Definition Of

That period in years, for the actual wall thickness of a pressure vessel to be reduced to the minimum required wall thickness of the pressure vessel for the pressure relief device set pressure by a known or assigned rate of corrosion.

4.1 Requirements

If the pressure vessel is to remain in service, the allowable conditions of service and the length of time before the next inspection shall be based on the conditions of the vessel as determined by the inspection and the remaining life of the vessel (ANSI/NB-23, 1987, National Board Inspection Code).

4.2 Determination Of Remaining Life Criticality Category

To determine the Remaining Life Criticality Category, follow the decision logic of Figure 5 and the following paragraphs whose numbering corresponds to the numbering of the logic diagram blocks.

4.2.1 Is P times V greater than 5,000 psi . ft.3? If the maximum operating pressure in PSI, times the volume in cubic feet, is greater than 5,000, assign life criticality category #1 and inspect annually. If the maximum operating pressure times the volume is less than 5,000, proceed with decision logic steps 2 through 20 to determine the remaining life of the pressure vessel.

4.2.2 To determine the corrosion rate, calculate the arithmetic mean for the head and shell for each year that historical data is available. Trend these mean values to determine at what rate the wall thickness is being lost to corrosion. Values shall be reported in inches/year.

4.2.3 Is the vessel susceptible to corrosion? If the vessel is made of a carbon steel it is probably susceptible to corrosion. If it is made of a corrosion resistant material, assign life criticality category #3 and inspect the vessel at a six year interval unless otherwise di[illegible]ted by the Risk Assessment or Mission Criticality [illegible]alysis.

4.2.4 Is there evidence of internal corrosion? Does the ultrasonic inspection records show that the vessel is corroding on the inside or does visual examination reveal external corrosion? If the vessel has been previously inspected, this data will be available in the Recertification File.

4.2.5 Can the corrosion rate be quantified? If the vessel has been in the Recertification Program for several years, then there should be sufficient ultrasonic thickness data for a trend analysis.

4.2.6 To determine the corrosion rate, calculate the arithmetic mean for the head and shell for each year that historical data is available. Trend these mean values to determine at what rate the wall thickness is being lost to corrosion. Values shall be reported in inches/year.

4.2.7 For new pressure vessels and for vessels for which service conditions are being changed, one of the following methods shall be employed to determine the probable rate of corrosion from which the remaining wall thickness, at the time of the next inspection, can be estimated:

a. the corrosion rate as established by data collected by the owner or user on pressure vessels in the same or similar service;

b. if data for the same or similar service are not available, the corrosion rate as estimated from the Inspector's knowledge and experience with pressure vessels in similar service;

c. if the probable corrosion rate cannot be determined by either of the above-mentioned methods, on-stream thickness determinations shall be made after approximately 1,000 hours of service. Subsequent sets of thickness measurements shall be taken after additional similar intervals until the corrosion rate is established (ANSI/NB-23, 1987, National Board Inspection Code).

4.2.8 Calculate the corrosion allowance based on the current inspection interval. The corrosion allowance is equal to twice the annual corrosion rate in years times the inspection interval in years (ANSI/NB-23, 1987, National Board Inspection Code, V-115).

4.2.9 Calculate the minimum required wall thickness in inches for the limiting section of the pressure vessel or zone. The minimum required wall thickness shall be the higher of the following as determined from the ASME Boiler and Pressure Vessel Code to which the vessel was designed:

a. the calculated thickness required for the pressure relieving device set pressure, static head or other loading and design metal temperature.

b. the minimum thickness permitted by the provision of the applicable ASME Boiler and Pressure Vessel Code section (ANSI/NB-23, 1987, National Board Inspection Code, V-106).

4.2.10 Is the required minimum wall thickness greater than or equal to the actual measured wall thickness? If the required minimum wall thickness is greater than or equal to the actual measured wall thickness, then the pressure relief device set pressure must be reduced or the inspection interval must be reduced or the pressure vessel must be replaced. In which case, we would proceed with decision logic steps 10 through 17. If the required minimum wall thickness is less than the actual measured wall thickness then we would proceed with decision logic steps 18 through 23 and determine the remaining life of the pressure vessel.

4.2.11 Is the pressure relief device set pressure more than 10% above the maximum operating pressure of the pressure vessel? If it is, then the set pressure can be reduced thereby decreasing the required minimum wall thickness.

4.2.12 If the pressure relief device set pressure is to be reduced, the pressure vessel or system must be derated. NHB 1700.6, Guide for In-service Inspection of Ground-Based Pressure Vessels and Systems defines Derated Vessel or System as "a vessel or system that has been judged to be unsafe, unsuitable or unnecessary for continued operation at its original design pressure and/or temperature limits and has been recertified to operate at a lesser pressure and/or temperature limit range.

4.2.13 Can the existing pressure relief device be reset to a pressure equal to the maximum operating pressure plus 10%? This will effectively derate the pressure vessel or system to its maximum operating pressure.

4.2.14 If the pressure relief device can be reset, reset it to the maximum operating pressure plus 10%. Some pressure relief devices are adjustable within a given pressure range and others are not.

4.2.15 If the pressure relief device is not adjustable or cannot be adjusted within its pressure range to the maximum operating pressure plus 10%, then it must be replaced with one that is set at the proper pressure or is adjustable within the required range.

4.2.16 Is the inspection and recertification interval greater than one year? If it is, then the interval can be reduced thereby decreasing the required minimum wall thickness. Reducing the inspection interval decreased the required minimum wall thickness because ANSI/NB-23, 1987, National Board Inspection Code, V-115 requires that a corrosion allowance of twice the estimated corrosion loss before the date of the next inspection be considered in the calculation for required wall thickness.

4.2.17 If the inspection interval is greater than one year, then it can be reduced and the corrosion allowance can be recalculated utilizing the new interval. After recalculating the corrosion allowance, you would re-enter the decision logic at step 8.

4.2.18 If the inspection interval is not greater than one year, then the vessel is no longer suitable for its intended use and must be replaced.

4.2.19 The maximum allowable working pressure, for the continued use of a pressure vessel, shall be established by the ASME Code section to which the vessel was built or by computation using the appropriate formulas in the latest edition of the Code if all essential details (such as upper and/or lower temperature limits for the specific materials, quality of materials and workmanship, knuckle radii of heads and reinforcement of openings) are known to definitely comply with the Code. In corrosive service the actual thickness as determined by inspection minus twice the estimated corrosion loss before the date of the next inspection, shall be used for calculating the MAWP. Suitable allowance shall be made for the other loadings in accordance with the applicable section of the ASME Code (ANSI/NB-23, 1987, National Board Inspection Code, V-115).

4.2.20 Where the corrosion rate controls the life of the pressure vessel, the remaining life shall be calculated by the following formula:

$$\text{Remaining life(years)} = \frac{t_{\text{actual}} \quad t_{\text{required}}}{\text{corrosion rate (inches per year)}}$$

Where:

t actual = thickness in inches measured at the time of inspection for the limiting section used in the determination of t required.

t required = minimum allowable thickness in inches for the limiting section of the pressure vessel or zone shall be the higher of the following as determined from the ASME Code to which the vessel was designed:

1. the calculated thickness required for the pressure relieving device set pressure, static head or other loading and design metal temperature.

2. the minimum thickness permitted by the provision of the applicable ASME Code section.

4.2.21 Is remaining life one to six years, six to twelve years or greater than twelve years?

4.2.22 If the remaining life is one to six years, assign Life Criticality Category #1.

4.2.23 If the remaining life is six to twelve years, assign Life Criticality Category #2.

4.2.24 If the remaining life is greater than twelve years, assign Life Criticality Category #3.

4.3 Documentation

The answers to all decision logic questions on Figure 5 along with the Life Criticality Category shall be documented on the Pressure Vessel Criticality Category and Inspection Interval Documentation Form (Appendix I) and be maintained in the Recertification System files.

REMAINING LIFE CRITICALITY DETERMINATION

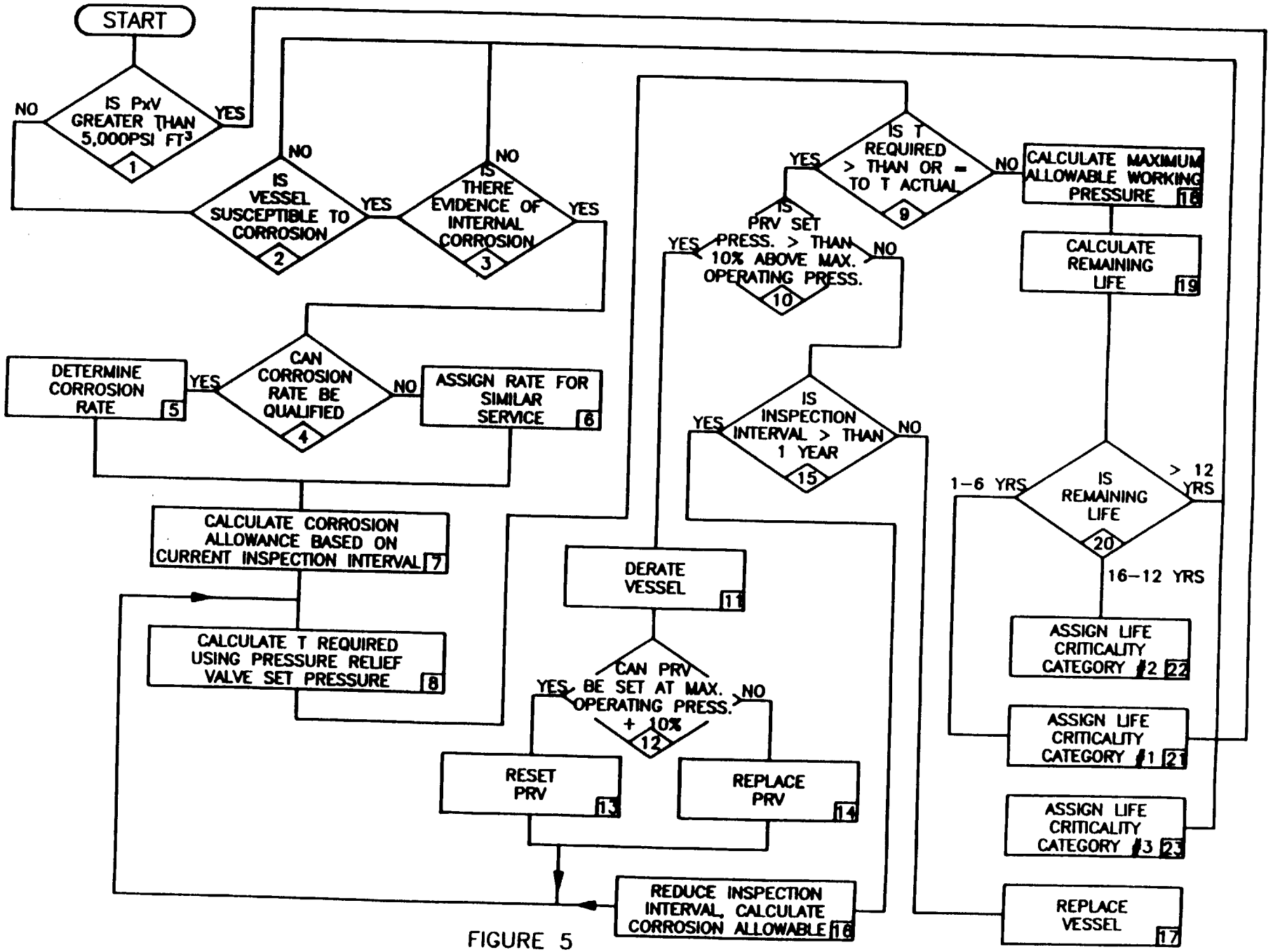

FIGURE 5

INSPECTION AND RECERTIFICATION REQUIREMENTS

5.0 Inspection and Recertification Requirements, Definition Of

Those in-service tests and inspections performed after a system has been initially put into service and those appropriate tests, inspections, examinations, and documentation by which a previously certified vessel or system is qualified to continue or be returned to operation for the recertification period (NASA, NHB 1700.6, Guide for In-service Inspection of Ground-Based Pressure Vessels and Systems, dated 18 January 1976).

5.1 Requirements

Periodic inspection is necessary to ensure that a system maintains its certification status. Results of inspections and tests performed for certification should provide the base for establishment of a comprehensive in-service inspection and recertification plan. The plan should provide confidence in structural integrity between recertification periods (NASA, NHB 1700.6, Guide for In-service Inspection of Ground-Based Pressure Vessels and Systems, dated 18 January 1976).

5.2 Inspection and Recertification Requirements

The in-service test, inspection and examination requirements and the recertification test, inspection and examination requirements for a six year recertification period are listed on Figures 6, 7 and 8 for criticality categories 1, 2 and 3 respectively. TMAC's and BMAC's that have not been previously certified or that are being certified for more stringent pressure and temperature service conditions should be subjected to all of the tests and inspections listed on Figures 6, 7 and 8 under Initial Examination for Recertification. TMAC's and BMAC's that are currently part of the Recertification Program may be entered into the 6 year recertification schedule at any outyear based on previously performed tests and inspections. This determination should be done on a case basis and the balancing of the annual work load should be considered when deciding where in the 6 year cycle that an individual TMAC/BMAC should be currently logged.

INSPECTION AND RECERTIFICATION REQUIREMENTS
PRESSURE SYSTEM NO. TMAC/BMAC

DESCRIPTION	TEST METHOD REQUIRED AT TIME INTERVALS (YEARS)					
	INITIAL EXAMINATION FOR RECERTIFICATION	0.5	1	2	3	6
Pressure Vessels and Supports	UT, PT, VE, VI**		UT, VE	VI		R
Vacuum Vessels and Supports						
Pressure Pumps and Compressors	VE		VE			R
Pressure Relief Valves (Liquids)						
Pressure Safety Valves (Gases)	VE, CRVT		VE	CRVT		R
Pressure Gages, Controllers, Reducers, Switches	VE, C		VE	C		R
Piping, Components and Supports	VE		VE			R
Flexible Hoses	VE, H-150		VE, H150			R
Expansion Joints						
Vibration Isolators	VE		VE			R
Rupture Disc						
Vacuum Gages						

R = Recertification
VE = External Visual Examination
CRVT = Relief Valve Certification Test (Reset)
C = Calibration (Certified by comparison with test gage)
UT = Ultrasonic (thickness) Test
PT = (Liquid) Penetrant Test
MT = Magnetic (Particle) Test
**VI = Internal Visual Examination (Only on Vessels Without Low Point Drain)
H150 = Hydrostatic Pressure

FIGURE 6

INSPECTION AND RECERTIFICATION REQUIREMENTS
PRESSURE SYSTEM NO. TMAC/BMAC

DESCRIPTION	TEST METHOD REQUIRED AT TIME INTERVALS (YEARS)					
	INITIAL EXAMINATION FOR RECERTIFICATION	0.5	1	2	3	6
Pressure Vessels and Supports	UT,PT,VE,VI**			VE	UT, VI	R
Vacuum Vessels and Supports						
Pressure Pumps and Compressors	VE			VE		R
Pressure Relief Valves (Liquids)						
Pressure Safety Valves (Gases)	VE, CRVT		VE	CRVT		R
Pressure Gages, Controllers, Reducers, Switches	VE, C			VE	C	R
Piping, Components and Supports	VE				VE	R
Flexible Hoses	VE, H-150		VE,H150			R
Expansion Joints						
Vibration Isolators	VE				VE	R
Rupture Disc						
Vacuum Gages						

R = Recertification
VE = External Visual Examination
CRVT = Relief Valve Certification Test (Reset)
C = Calibration (Certified by comparison with test gage)
UT = Ultrasonic (thickness) Test
PT = (Liquid) Penetrant Test
MT = Magnetic (Particle) Test
**VI = Internal Visual Examination (Only on Vessels Without Low Point Drain)
H150 = Hydrostatic Pressure

FIGURE 7

INSPECTION AND RECERTIFICATION REQUIREMENTS
PRESSURE SYSTEM NO. TMAC/BMAC

DESCRIPTION	TEST METHOD REQUIRED AT TIME INTERVALS (YEARS)					
	INITIAL EXAMINATION FOR RECERTIFICATION	0.5	1	2	3	6
Pressure Vessels and Supports	UT,PT,VE,VI**				VE	R
Vacuum Vessels and Supports						
Pressure Pumps and Compressors	VE				VE	R
Pressure Relief Valves (Liquids)						
Pressure Safety Valves (Gases)	VE, CRVT		VE	CRVT		R
Pressure Gages, Controllers, Reducers, Switches	VE, C				VE, C	R
Piping, Components and Supports	VE				VE	R
Flexible Hoses and	VE, H-150		VE,H150			R
Expansion Joints						
Vibration Isolators	VE				VE	R
Rupture Disc						
Vacuum Gages						

R = Recertification
VE = External Visual Examination
CRVT = Relief Valve Certification Test (Reset)
C = Calibration (Certified by comparison with test gage)
UT = Ultrasonic (thickness) Test
PT = (Liquid) Penetrant Test
MT = Magnetic (Particle) Test
**VI = Internal Visual Examination (Only on Vessels Without Low Point Drain)
H150 = Hydrostatic Pressure

FIGURE 8

REFERENCES

1. NASA NHB 1700.6 Guide for In-service Inspection of Ground-Based Pressure Vessels and Systems, 18 January 1976.

2. NASA NMI 1710.3B Design, Inspection and Certification of Pressure Vessels and Pressurized Systems, 23 February 1982.

3. NASA GMI 1710.4A Design, Inspection and Certification of Pressure Vessels and Pressurized Systems (Recert), 28 November 1985.

4. ASME Section VIII, Divisions 1&2, American Society of Mechanical Engineers, Boiler and Pressure Vessel Code, 1986 Edition.

5. ANSI/NB-23, Rev. 6, 1987, National Board Inspection Code.

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APPENDIX I

TEST REPORT
RECERT SYSTEM
NSI-43R- S-

PRESSURE VESSEL CRITICALITY CODE AND INSPECTION INTERVAL DOCUMENTATION FORM

I. Risk Assessment

1. Hazard _____

   A. Severity Classification _____

   B. Probability Estimate _____

2. Risk Assessment Code (RAC) _____

3. Risk Assessment Criticality Category _____

II. Mission Essentiality

1. Is Pressure Vessel Required to Support Flight Operations? _____

2. Is There a Redundant Support Capability? _____

3. Is the Cost of a Maximum Credible Failure of the Vessel Greater Than $5,000? _____

4. Mission Essentiality Criticality Category: _____

III. Remaining Life

1. Is PV Greater Than 5,000? _____ PV = _____ PSI . FT3

2. Is Pressure Vessel Susceptible to Corrosion? _____

3. Is There Evidence of Internal Corrosion? _____

4. Can Corrosion Rate Be Quantified? _____

5. Calculated Corrosion Rate: S. _____ H. _____

6. Assigned Corrosion Rate: S. _____ H. _____

7. Corrosion Allowance: S. _____ H. _____

8. Required Minimum Thickness: S. _____ H. _____

9. Is T Required ≥ T Actual? S. _____ H. _____

10. Is PRV Set More Than 10% Above Maximum Operating Pressure: _____

11. Derate Pressure Vessel To: _____ PSI

PRESSURE VESSEL CRITICALITY CODE
AND INSPECTION INTERVAL
DOCUMENTATION FORM

12. Can PRV Be Reset to Operating Pressure + 10%?_____

13. PRV Reset Pressure:_____ PSI

14. Replace PRV:_____

15. Is Inspection Interval Greater Than 1 Year?_____

16. A) New Inspection Interval:_____

    B) Recalculated Corrosion Allowance:_____

17. Replace Vessel:_____

18. Maximum Allowable Working Pressure:_____

19. Remaining Life:_____

20. Life Criticality Category:_____

IV. Pressure Vessel Criticality Code:_____